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GREEN MUSSELS CULTURE (*Perna viridis* L.) IN THE MANGROVE AREA POTENTIALLY IMPACTED BY HEAVY METAL

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ABSTRAK

Tujuan penelitian ini adalah untuk : 1). Menentukan jenis kolektor dan ketinggian pemasangannya yang paling efektif pada budidaya budidaya kerang hijau (*Perna viridis* L.) terdampak pencemaran logam berat di perairan yang ber-mangrove dan tidak ber-mangrove; 2) Mengetahui kandungan logam berat khususnya timbal (Plumbum, Pb), tembaga (Cuprum, Cu), kadmium (Cadmium, Cd) dan merkuri (Hydragyrum, Hg) pada budidaya kerang hijau. Penelitian ini dilaksanakan selama 6 bulan pada bulan April-September 2018 bertempat di wilayah perairan pantai Karangdempel, Kecamatan Losari, Kabupaten Brebes. Metode yang digunakan dalam penelitian ini adalah metode eksperimen dengan cara menarik hubungan sebab-akibat dari jenis bahan dan ketinggian kolektor kerang hijau dari dasar perairan serta keberadaan mangrove dengan pertumbuhan kerang hijau hasil budidaya. Hasil penelitian menunjukan bahwa : 1) Pertumbuhan kerang hijau selama 6 -7 bulan masa pemeliharaan mencapai panjang cangkang 7 – 9 cm dengan bobot 10-13 gram per ekor dan jumlah kerang 23-30 ekor per kolektor. Kolektor kerang yang paling efektif terbuat dari karung waring, dan dipasang pada ketinggian 30 cm dari dasar perairan. Jumlah kerang hijau per kolektor kerang di lokasi ber-mangrove lebih banyak dibandingkan dengan lokasi tidak ber-mangrove, sedangkan pertumbuhan panjang cangkang dan bobot kerang hijau relatif sama di kedua lokasi tersebut; 2) Secara umum kandungan logam berat di air laut dan pada daging kerang hijau masih berada dalam batas yang diperbolehkan, kecuali kandungan Cu pada daging kerang hijau melebihi batas yang diperbolehkan menurut Standar Nasional Indonesia, namun relatif masih aman menurut ketentuan SK Dirjen Pengawasan Obat dan Makanan, Departemen Kesehatan RI, No. 03725/B/SK/1989. Kandungan Pb pada sedimen baik di lokasi budidaya kerang hijau maupun di sodetan Sungai Cisanggarung masih berada dalam batas aman. Adapun kandungan Cd, Cu dan Hg pada sedimen cenderung tinggi pada batas maksimum yang diperbolehkan, bahkan kandungan Cu di sodetan Sungai Cisanggarung mencapai dua kali dari nilai maksimum yang diperbolehkan. Kandungan logam berat di lokasi penelitian yang ber-mangrove dengan yang tidak ber-mangrove relatif tidak berbeda nyata sebagai akibat dari mangrove hasil rebiosasi yang ada masih didominasi jenis semai dan anakan sehingga indeks nilai penting/peranannya belum berpengaruh terhadap kualitas ekologis-ekonomis perairan.

Kata kunci : kerang hijau, logam berat, mangrove

ABSTRACT

The purposes of this study are: 1) to investigate the types of different collectors and their most effective height of installation in the green mussels cultination (*Perna viridis* L.) impacted by heavy metal pollution in mangrove and non-mangrove waters; 2) to determine the content of heavy metals, especially Plumbum (Pb), Cuprum (Cu), Cadmium (Cd), and Hydragyrum (Hg) in green mussels cultivation. This research was conducted for 6 months from April to September 2018 in the coastal area of Karangdempel, Losari Sub District, Brebes Regency. The method used in this research was experimental. The results showed that: 1) the growth of green mussels after 6 months period of maintenance reached 7-9 cm long, weighing 10-13 grams per head and yielded 23-30 heads per collector. The most effective mussel collector was made from net sacks installed at a height of 30 cm from the bottom of the water. The number of green mussels per collector was more in mangrove location compared to those in the non-mangrove location, while their growth in length and weight were relatively the same in both locations; 2) in general, the heavy metal content in seawater and in the green mussel meat are still within the

permissible limits of the Indonesian National Standard, except for the Cu content in the green mussel meat exceeding the allowable limit; but it was relatively still safe accoring to the Decree of the Director General of Drug Control and Food, Indonesian Ministry of Health, No. 03725 / B / SK / 1989. Pb content in sediments in both location of green mussels cultivation and the Cisanggarung River basin is still within the safe limits. The content of Cd, Cu, and Hg in sediments tends to be high at the maximum permissible limit, even the Cu content in the Cisanggarung River reached twice the maximum allowable value. The heavy metal content in the research areas, both in mangrove and non-mangrove areas, was relatively not different as a result of mangrove reforestation dominated by seedlings and saplings with little influence on the quality of the water ecologically and economically.

Keywords: green mussels, heavy metals, mangroves

Introduction

Coastal waters are integral parts of the sea and coastal land with a complex relationship. The condition of the coastal waters is influenced by the activity in the watershed which empties into the coastal waters as well as the activities in the sea which are still relatively close to the coastal waters. The coastal waters of Karangdempel in the Losari Subdistrict, Brebes Regency as an estuary area of the Cisanggarung River Basin are likely to be affected by industrial wastes from Kuningan Regency, Cirebon City, and Cirebon Regency. In 2016, there were 5836 companies in Kuningan. Among them there were 3250 clothing companies and 2476 food companies (Kuningan Regency Central Bureau of Statistics, 2017). In Cirebon Regency, there were 841 companies in the chemical sector and 823 mining companies in 2016 (Cirebon Regency Central Bureau of Statistics, 2017) and in the same year in Cirebon City, there were 45 companies potentially producing waste (Cirebon City Central Statistics Agency, 2017). The industrial waste often contains heavy metals which can endanger the lives of biota in river estuary waters. Several studies conducted by Heriyanto (2011), Kusumastuti, et al. (2011) and Supriyantini and Soenardjo (2015), showed that the presence of mangroves can minimize or reduce the content of heavy metal contamination in the waters.

On the other hand, Karangdempel coastal waters are protected from large waves due to the presence of sand dunes so it is very strategic to be used as a development area for green mussels (*Perna viridis* L.) cultivation (Fisheries and Marine Service Office of Brebes Regency, 2008). Cultivation of green mussels is feasible to be developed because it is relatively easy, reasonable in costs and does not need to provide seeds specifically. This can be used as an additional business alternative for fishermen around Karangdempel, especially during the famine (Brebes Regency Indonesian Fishermen Association, 2017).

The research purposes were :

1. to investigate the types of different collectors and their most effective height of installation in the green mussels cultivation (*Perna viridis* L.) impacted by heavy metal pollution in mangrove and non-mangrove waters; 2) to determine the content of heavy metals, especially Pb, Cu, Cd, and Hg in green mussels cultivation.

This research was conducted from April to September 2018 in the coastal area of Karangdempel, Losari Sub District, Brebes Regency.

Materials and Methods

The study used an experimental method adopted from Siregar (2013), by drawing a causal relationship from the type of material and the height of the green mussels collector from the bottom of the sea and the presence of mangroves with green mussels growth from aquaculture in Karangdempel coastal, Losari Sub District, Brebes Regency. Green mussels cultivation was done by floating box technique in coastal waters with a water depth of 125 cm - 150 cm. Cultivation construction was designed with the type of mussels collector material made from coconut fiber, palm fiber, and nets sacks installed at the height of the collector's installation 20 cm, 30 cm, and 40 cm from the mangrove and non-mangrove bottom.

The relationship of the growth of green mussels with the type and height of mussels collectors from the bottom of the waters and the presence of mangroves was analyzed by Analysis of Variance (Anova) using the help of SPSS software (Siregar, 2013).

Results And Discussions

Location Conditions

The selection of research site was done under some criterias i.e. it should be protected from large waves assumed to be influenced by the flow of the Cisanggarung River, the base of mud-sandy waters, the depth of the waters 120-130 cm, and the surrounding mangroves. The chosen location is the Karangdempel coastal area at the western end of Pasir Island, which is about 200 meters from Pasir Island to the south. Some of the Karangdempel beaches are overgrown with mangroves, alternating with mud-sandy beach land which is alluvial soil, like the coastal soil type of Brebes Regency to Tegal (Wibowo, et al., 2015). The land is still relatively young but can support adequate water fertility for mangrove life. The waters with a lot of mangroves are ones of the habitats favored by green mussels (*Perna viridis* L.). Green mussels are found mostly in bay waters, mangrove estuaries with sandy mud waters, in sites with adequate lighting and water movement and in sites in which salt levels are not too high (Sari and Harlyan, 2015).

There are two main types of mangrove vegetation found at Karangdempel coastal, namely *Rhizophora* sp. and *Avicennia* sp. with total species density, trees, saplings and seedlings each of 486 individual/ha., 26 individual/ha., 158 individual/ha., and 302 individual/ha. The closing of mangrove species is worth 7-20%. Relatively large density values of species of seedlings and tillers and relatively small types of closure are indicated by the narrow shade of mangrove vegetation canopy because the mangrove vegetation is still dominated by sapling and seedling categories compared to the tree category as a result of the influence of mangrove reforestation in recent years. Domination of *Rhizophora* sp. is higher than *Avicennia* sp. because *Rhizophora* sp. is more easily seeded and planted during reforestation. Mangrove vegetation in Karangdempel coastal waters only has an ecological role with a low to moderate category which is shown by the range of important value index (IVI) which only ranges from 1 to 300 as stated by Bengen (2002). Mangrove vegetation in Karangdempel beach is categorised very rare and in a damaged condition indicated by the value of the Normalized Difference Vegetation Index (NDVI) of 0.096367 (Decree of the State Minister of Environment No.201 of 2004).

Green Mussels Growth

The cultivation of green mussels is indicated by the average mussels length, weight, and number of green mussels per collector mussels made from coir, palm fiber and nets sacks which are installed at a height of 20 cm, 30 cm, and 40 cm from the bottom of the mangrove and non-mangrove waters. Green mussels growth at the end of the cultivation period (6 months maintenance period) is presented in Tables 1, 2 and 3.

Table 1. The average length of shell (cm) of green mussels (*Perna viridis* L.) at the end of the cultivation period

	The height of the mussels collector from the bottom of the water											
	20 cm				30 cm				40 cm			
	Repetition				Repetition				Repetition			
	1	2	3	Average	1	2	3	Average	1	2	3	Average
I. Non-mangrove												
a. Coir collector	7,10	7,10	7,10	7,10±0,0	8,30	8,10	8,20	8,20±0,1	8,00	8,00	8,00	8,00±0,0
b. Fiber collector	7,10	7,00	7,20	7,10±0,1	8,10	8,20	8,30	8,20±0,1	7,20	7,00	7,10	7,10±0,1
c. Nets collector	8,20	8,10	8,30	8,20±0,1	9,50	9,40	9,60	9,50±0,1	8,20	8,10	8,00	8,10±0,1
II. Mangrove												
a. Coir collector	7,10	7,10	7,10	7,10±0,0	8,10	8,10	8,10	8,10±0,0	7,30	7,30	7,30	7,30±0,0
b. Fiber collector	8,20	8,20	8,20	8,20±0,0	9,30	9,10	9,20	9,20±0,1	8,10	8,20	8,00	8,10±0,1
c. Nets collector	8,10	8,30	8,20	8,20±0,1	9,30	9,20	9,40	9,30±0,1	8,30	8,10	8,20	8,20±0,1

Source: Results of the study, 2018

The growth of green mussels with indicators of the shell length at the end of the maintenance period is influenced by the height of the mussels collector (sig = 0.001) and the type of mussels collector material (sig = 0.005) but not affected by the absence of mangrove (sig = 0.227). The growth of the green mussels on the collectors which are hung at a height of 30 cm is very real and faster than the green mussels in the collector with a height of 20 cm and 40 cm from the bottom of the water. The growth of green mussels on nets collectors is significantly different and faster than those made from coir and palm fiber. The growth of green mussels in mangrove waters is not significantly different, relatively the same as those in mangrove waters with no mangroves.

Table 2. The average weight of green mussels (*Perna viridis* L.) at the end of the cultivation period

	The height of the mussels collector from the bottom of the water											
	20 cm				30 cm				40 cm			
	Repetition				Repetition				Repetition			
	1	2	3	Average	1	2	3	Average	1	2	3	Average
I. Not mangrove												
a. Coir collector	11	9	10	10±1	12	13	11	12±1	9	11	10	10±1
b. Fiber collector	12	11	10	11±1	13	12	11	12±1	10	10	10	10±0
c. Nets collector	12	13	11	12±1	13	13	13	13±0	13	12	11	12±1
II. Mangrove												
a. Coir collector	12	11	10	11±1	12	13	11	12±1	13	11	12	12±1
b. Fiber collector	10	12	11	11±1	13	13	13	13±0	12	10	11	11±1
c. Nets collector	12	12	12	12±0	13	13	13	13±0	11	12	10	11±1

Source: Results of the study, 2018

The growth of green mussels with mussels weight indicators at the end of the maintenance period is influenced by the height of the mussel collector (sig = 0.001) and the type of collector material (sig = 0.024) but not affected by the absence of mangrove (sig = 0.128). The weight of the green mussels on the collector which is hung at a height of 30 cm is significantly different and faster than the green mussels in the collector with a height of 20 cm and 40 cm from the bottom of the water. The weight of the green mussels in the collector of mussels made of nets is significantly different and faster than the green mussels in the collector of coir and palm fiber. The weight of green mussels in mangrove waters is not significantly different from those in non-mangrove waters.

Table 3. Total density of green mussels (*Perna viridis* L.) per collector at the end of the cultivation period

	The height of the mussels collector from the bottom of the water											
	20 cm				30 cm				40 cm			
	Repetition				Repetition				Repetition			
	1	2	3	Average	1	2	3	Average	1	2	3	Average
I. Not mangrove												
a. Coir collector	28	21	23	24±3,60	24	29	25	26±2,65	21	24	27	24±3,00
b. Fiber collector	20	27	22	23±3,60	26	28	30	28±2,00	25	28	22	25±3,00
c. Nets collector	25	27	29	27±2,00	31	28	31	30±1,73	30	25	29	28±2,65
II. Mangrove												
a. Coir collector	26	27	25	26±1,00	25	30	29	28±2,65	27	28	23	26±2,65
b. Fiber collector	27	28	29	28±1,00	30	30	30	30±0,00	25	27	23	25±2,00
c. Nets collector	27	27	30	28±1,73	28	30	32	30±2,00	29	30	28	29±1,00

Source: Results of the study, 2018

The amount of green mussels per collector at the end of the maintenance period is influenced by the height of the mussels collector (sig = 0.001) and the type of mussels collector material (sig = 0.001) and the absence of mangrove plants (0.005). The number of green mussels per collector that is hung at a height of 30 cm is significantly different and more in number than the green mussels in the collector with a height of 20 cm and 40 cm from the bottom of the water. The amount of green mussels per collector made of nets is significantly different and more in number than that of green mussels in collectors made from coir and palm fiber. The amount of green mussels per collector in mangrove waters is being significantly different and more abundant compared to those in non-mangrove waters.

Water Quality Cultivation Media

The results of measurements of water quality of green mussels cultivation media (*Perna viridis* L.) during the study, are generally presented in Tables 4 and 5.

Table 4. Aquaculture Media Water Quality Measurement Results

No	Parameter	Value (Station: S 06°47''39.9'' E 108°51'32.9'')
1	Temperature	33 ^{0}C
2	Air temperature	34 ^{0}C
3	Depth	125 cm
4	Brightness	30 cm
5	Water pH	7.4
6	Soil pH	7,1
7	Salinity	33 ‰
8	O_2	8.68 ppm
9	Nitrous	0.03 ppm
10	Nitrite	0.001 ppm
11	Ammonia	0.33 ppm
12	Phosphate	0.002 ppm
13	Current speed	0,1 m/sec.
14	BOD	5.30 ppm
15	Colors of water	Blue-green
16	Plankton	*Synedra ulva, Sphatio sucatum, Ploesam triacatum, Rhopalodiaventricose, Gramstopere serpentine, Pleurotaenium baculoides*

Source: Integrated Laboratory of the Faculty of Fisheries and Marine Sciences, Pancasakti University, Tegal (2018)

Table 5. Results of Analysis of Heavy Metal Content of Cu, Cd, Pb, and Hg

1. Green mussels station 1

	Unit	Test Result	Test Method	Information
Lead, Pb	mg/kg	0,470	AAS	The location is not a mangrove
Cadmium, Cd	mg/kg	< 0,010	AAS	The location is not a mangrove
Copper, Cu	mg/kg	2,070	AAS	The location is not a mangrove
Mercury, Hg	mg/kg	< 0,001	AAS	The location is not a mangrove

2. Green mussels station 2

Parameters	Unit	Test Result	Test Method	Information
Lead, Pb	mg/kg	0,560	AAS	A mangrove location
Cadmium, Cd	mg/kg	< 0,010	AAS	A mangrove location
Copper, Cu	mg/kg	2,060	AAS	A mangrove location
Mercury, Hg	mg/kg	< 0,001	AAS	A mangrove location

3. Seawater station 1

Parameters	Unit	Test Result	Test Method	Information
Lead, Pb	mg/lt	< 0,003	APHA	The location is not a mangrove
Cadmium, Cd	mg/lt	< 0,001	APHA	The location is not a mangrove
Copper, Cu	mg/lt	< 0,001	APHA	The location is not a mangrove
Mercury, Hg	mg/lt	< 0,001	APHA	The location is not a mangrove

4. Seawater station 2

Parameters	Unit	Test result	Test Method	Information
Lead, Pb	mg/lt	< 0,003	APHA	A mangrove location
Cadmium, Cd	mg/lt	< 0,001	APHA	A mangrove location
Copper, Cu	mg/lt	< 0,001	APHA	A mangrove location
Mercury, Hg	mg/lt	< 0,001	APHA	A mangrove location

5. Seawater of crossing of Cisanggarung River

Parameters	Unit	Test Result	Test Method	Information
Lead, Pb	mg/lt	< 0,003	APHA	The crossing of Cisanggarung River
Cadmium, Cd	mg/lt	< 0,001	APHA	The crossing of Cisanggarung River
Copper, Cu	mg/lt	< 0,001	APHA	The crossing of Cisanggarung River
Mercury, Hg	mg/lt	< 0,001	APHA	The crossing of Cisanggarung River

6. Sea bed sediment station 1

Parameters	Unit	Test Result	Test Method	Information
Lead, Pb	mg/kg	25,820	The US.EPA SW 846/3050 B-1996 SM 3111B-2012	The location is not a mangrove
Cadmium, Cd	mg/kg	1,683	The US.EPA SW 846/3050 B-1996 SM 3111B-2012	The location is not a mangrove
Copper, Cu	mg/kg	24,430	The US.EPA SW 846/3050 B-1996 SM 3111B-2012	The location is not a mangrove
Mercury, Hg	mg/kg	0,146	The US.EPA SW 846/3050 B-1996 SM 3111B-2012	The location is not a mangrove

7. Seabed sediment station 2

Parameters	Unit	Test Result	Test Method	Information
Lead, Pb	mg/kg	33,250	The US.EPA SW846/3050 B-1996 SM 3111B-2012	A mangrove location
Cadmium, Cd	mg/kg	2,089	The US.EPA SW846/3050 B-1996 SM 3111B-2012	A mangrove location
Copper, Cu	mg/kg	29,700	The US.EPA SW 846/3050 B-1996 SM 3111B-2012	A mangrove location
Mercury, Hg	mg/kg	0,182	The US.EPA SW 846/3050 B-1996 SM 3111B-2012	A mangrove location

8. Basic sediments of the crossing of Cisanggarung River

Parameters	Unit	Test Result	Test Method	Information
Lead, Pb	mg/kg	31,600	The US.EPA SW 846/3050 B-1996 SM 3111B-2012	The crossing of Cisanggarung River
Cadmium, Cd	mg/kg	2,084	The US.EPA SW 846/3050 B-1996 SM 3111B-2012	The crossing of Cisanggarung River
Copper, Cu	mg/kg	70,850	The US.EPA SW 846/3050 B-1996 SM 3111B-2012	The crossing of Cisanggarung River
Mercury, Hg	mg/kg	0,174	The US.EPA SW 846/3050 B-1996 SM 3111B-2012	The crossing of Cisanggarung River

Source: Laboratory of the Center for Industrial Pollution Prevention Technology (BBTPPI) Semarang (2018).
Description: AAS (Atomic Absorption Spectrophotometer).

Heavy metals contained in seawater and green mussels meat are still below the hazardous limits, except for copper (Cu) content in green mussels meat which reaches 2,046 - 2,070 mg / kg of meat, exceeding the permissible limit of 1.0 mg / kg green mussels meat according to Indonesian National Standards (Government regulation number 82 of 2001, Decree of the Minister of Environment number 51 of 2004), but still below 20.0 mg / kg as the maximum limit according to the provisions of the Decree of the Director General of Drug and Food Control, Ministry of Health Republic of Indonesia, number 03725 / B / SK / 1989. As for the sediments in the location of green mussels cultivation and in the Cisanggarung River basin, the Pb content is still within the safe limit. On the other hand, Cd, Cu, and Hg contained in the sediments in these three locations tend to be at the maximum permissible limit, even the Cu content in the Cisanggarung River channel reaches twice the maximum allowable value.

The heavy metal content in green mussels meat, seawater, and sediment in the mangrove study sites with non-mangrove sites is not significantly different at the 95% confidence level. This is indicated by the calculated F value in the t-test of 0.003 with a significance of 0.954. Value t (count) = -0.028 while from Table t obtained value of t (α / 2; df) = t (0.025; 14) = 2.14479 so that obtained: -t table <t count <+ t table = - 2, 14479 <-0,028 <+ 2,14479, meaning there is no difference at 95% significance. This is possible because the condition of mangrove vegetation in Karangdempel beach is categorized as damaged with a range of important value index (IVI) 1 - 300 (Suyono et al., 2015) so that it only has a low to moderate ecological-economic role (Bengen, 2002). The relatively young age of mangrove vegetation resulting from reforestation has

not been able to provide a significant positive impact on the coastal waters ecosystem including the heavy metal content. Good mangrove management will be able to increase coastal productivity including green mussels production (Fithor, et al., 2018).

Conclusions

1. The growth of green mussels (*Perna viridis* L.) in 6-7 months period of maintenance reaches 7-9 cm long, weighing 10-13 grams per tail, and the number of mussels is 23-30 per collector. The most effective collector mussels are made of nets sacks and are installed at a height of 30 cm from the bottom of the water. The number of green mussels per mussels collector in mangrove locations is more compared to those in non-mangrove locations, while the growth of mussels length and weight of green mussels is relatively the same in both locations.
2. In general, heavy metal content in seawater and in green mussels meat is still within the permissible limits, except the copper (Cu) content in green mussels meat which exceeds the allowable limit according to Indonesian National Standards, but is it relatively safe according to the provisions of the Decree of the Director General of Drug Control and Food, Indonesian Ministry of Health, number : 03725 / B / SK / 1989. Pb content in sediments both in the location of green mussels cultivation and in the Cisanggarung River basin is still within safe limits. The content of Cd, Cu, and Hg in sediments tends to be high at the maximum permissible limit, even the Cu content in the Cisanggarung River reaches twice the maximum allowable value. The heavy metal content in the mangrove research sites with non-mangrove is relatively not significantly different as a result of the mangrove results of reforestation which are still dominant seedlings and saplings so that the index of importance/role has not yet affected the ecological-economic quality of the waters.

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